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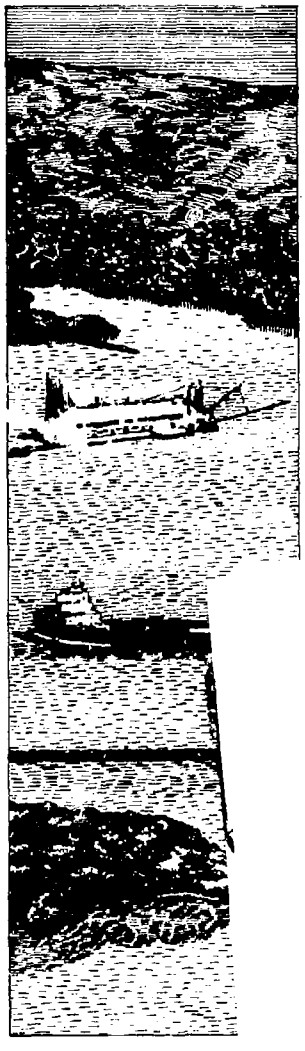

DREDGING RESEARCH PROGRAM

CONTRACT REPORT DRP-95-1

GEOSITE: GEOTECHNICAL SITE INVESTIGATION METHODS

User's Guide

by

S. Joseph Spigolon

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September 1995

Final Report

Approved For Public Release; Distribution Is Unlimited

Prepared for Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit 32471

Monitored by U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

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The Dredging Research Program (DRP) is a seven-year program of the U.S. Army Corps of Engineers. DRP research is managed in these five technical areas:

Area 1 - Analysis of Dredged Material Placed in Open Water
Area 2 - Material Properties Related to Navigation and Dredging
Area 3 - Dredge Plant Equipment and Systems Processes
Area 4 - Vessel Positioning, Survey Controls, and Dredge Monitoring Systems
Area 5 - Management of Dredging Projects

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Dredging Research Program Report Summary

US Army Corps of Engineers
Waterways Experiment Station

GEOSITE: Geotechnical Site Investigation Methods; User's Guide (CR DRP-95-1)

ISSUE: The objective of a geotechnical site investigation for a dredging project is to obtain the most complete and accurate estimate of the location and character of the materials to be dredged that is possible within the limits of available time, money, and practicality. The data from a site investigation are summarized in a predicted geotechnical subbottom profile. The amount to be spent on a site investigation is directly related to the amount that the bid price and the total cost involved in processing claims for changed conditions can be reduced by the availability of a comprehensive geotechnical site description.

RESEARCH: Knowledge-based expert systems (KBES) are computer programs that use a knowledge base of expert-derived rules for providing guidance. Rules in the knowledge base are in the form of "IF-THEN" statements that can incorporate judgement, experience, empirical rules of thumb, intuition, and other expertise as well as proven functional relationships and experimental evidence. The database of rules of a KBES is independent of the inference engine (program control); therefore, the ability to add new or expanded knowledge to the knowledge base is a major feature of a KBES.

The KBES described in this report is an outgrowth of a Dredging Research Program (DRP) work unit that involves the development of geotechnical descriptors to indicate, or infer, dredgeability of sediments to be dredged. The initial knowledge base was based on literature surveys, personal experiences, and comments made during several workshops.

SUMMARY: The GEOSITE program provides guidance, from geotechnical engineering experts, for the selection of equipment and methods for a subsurface investigation of an individual exploration site for a dredging project. It is intended to be used by engineers, estimators, and contractors, serving as a personal geotechnical engineering consultant.

AVAILABILITY OF REPORT: The report is available through the Interlibrary Loan Service from the U.S. Army Engineer Waterways Experiment Station (WES) Library, telephone number (601) 634-2355. National Technical Information Service (NTIS) report numbers may be requested from WES Librarians.

To purchase a copy of the report, call NTIS at (703) 487-4780.

About the Authors: Dr. S. Joseph Spigolon is an engineering consultant, SJS Corporation, Coos Bay, OR, and Dr. Reda M. Bakeer is an Associate Professor, Department of Civil and Environmental Engineering, Tulane University, New Orleans, LA. The study was conducted under the technical oversight of Dr. Jack Fowler, Principal Investigator, Geotechnical Laboratory, WES. For further information about the DRP, contact Mr. E. Clark McNair, Jr., Manager, DRP, at (601) 634-2070.

September 1995

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Dredging Research Program

Contract Report DRP-95-1
September 1995

GEOSITE: Geotechnical Site Investigation Methods

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by S. Joseph Spigolon

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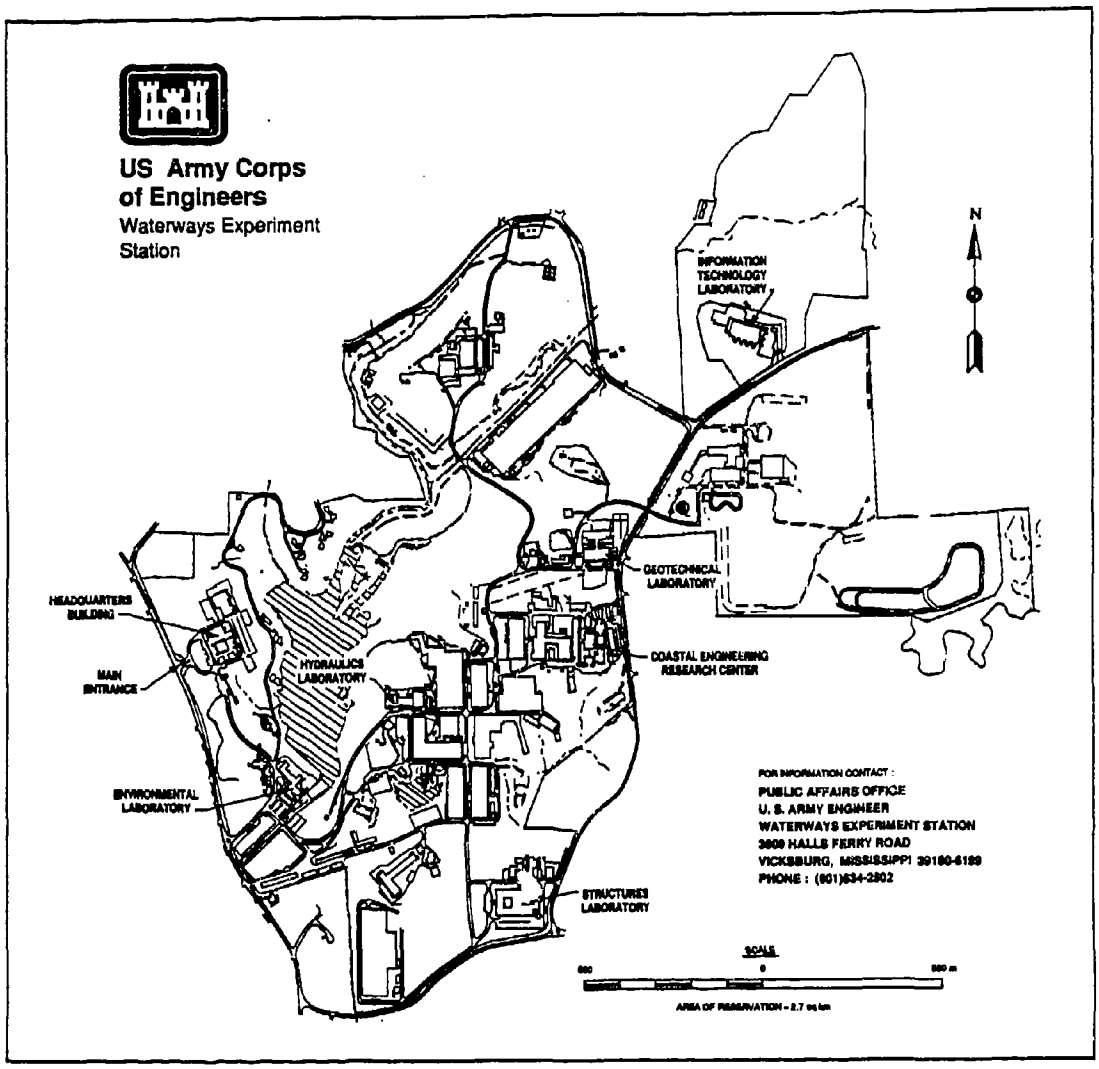

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Contents

Preface vii

1—Introduction 1

Objective of GEOSITE 1
Program Overview 2
Background 4
Outline of This User's Guide 4

2—Installing GEOSITE 5

System Requirements 5
Hard Disk Installation—Windows Version 6
Possible Video Problem—Windows Version 6
Hard Disk Installation—DOS Version 7
READ.ME and MANUAL Files 8

3—Operating the GEOSITE Program 9

Navigating the GEOSITE Program 9
Regular (Complete) Investigation Displays 13
Density Display 24
Rock Surface Display 25
Discussion Facility 26

4—The GEOSITE Programming Environment 28

Knowledge-Based Expert Systems 28
Selection of the Programming Environment 29
Relationship to Published Reports 31

5—Modifying and Upgrading GEOSITE 32

Appendix A: Files Contained in the GEOSITE Distribution Diskettes ... A1

Appendix B: GEOSITE Discussion Topics B1

SF 298

Contents

Preface vii

1—Introduction 1

Objective of GEOSITE 1
Program Overview 2
Background 4
Outline of This User's Guide 4

2—Installing GEOSITE 5

System Requirements 5
Hard Disk Installation—Windows Version 6
Possible Video Problem—Windows Version 6
Hard Disk Installation—DOS Version 7
READ.ME and MANUAL Files 8

3—Operating the GEOSITE Program 9

Navigating the GEOSITE Program 9
Regular (Complete) Investigation Displays 13
Density Display 24
Rock Surface Display 25
Discussion Facility 26

4—The GEOSITE Programming Environment 28

Knowledge-Based Expert Systems 28
Selection of the Programming Environment 29
Relationship to Published Reports 31

5—Modifying and Upgrading GEOSITE 32

Appendix A: Files Contained in the GEOSITE Distribution Diskettes ... A1

Appendix B: GEOSITE Discussion Topics B1

SF 298

List of Figures

Figure 1. Choice of objective for the GEOSITE guidance session 11

Figure 2. Sediment type selection screen 12

Figure 3. Flow diagram of GEOSITE complete investigation program 13

Figure 4. Sampler suitability screen 14

Figure 5. Selection of strength test type 16

Figure 6. Field strength test suitability screen 17

Figure 7. Laboratory strength test suitability screen 17

Figure 8. Rock strength test suitability screen 18

Figure 9. Report information input screen 19

Figure 10. Suitability of methods of accessing testing depth 21

Figure 11. Selection of water conditions screen 21

Figure 12. Suitability of work platforms screen 22

Figure 13. Suitability of material identification tests screen 23

Figure 14. Field density test methods screen 24

Figure 15. Finding rock surface methods screen 25

Figure 16. Components of a knowledge-based expert system (KBES) ... 29

Preface

This user's guide and the associated computer program were prepared under Contract No. DACW39-92-C-0098 (Neg.), dated 22 July 1992, for the U.S. Army Engineer Waterways Experiment Station (WES) under Dredging Research Program (DRP) Technical Area 2, Work Unit No. 32471, "Descriptors for Bottom Sediments to be Dredged." The DRP is sponsored by Headquarters, U.S. Army Corps of Engineers. Technical Monitor for Technical Area 2 was Mr. Barry W. Holliday; Chief Technical Monitor was Mr. Robert H. Campbell.

This user's guide was written by Dr. S. Joseph Spigolon, Engineering Consultant, Coos Bay, OR, and Dr. Reda M. Bakeer, Associate Professor, Department of Civil and Environmental Engineering, Tulane University, New Orleans, LA, under the technical oversight of Dr. Jack Fowler, Principal Investigator, Soil Mechanics Branch (SMB), Soil and Rock Mechanics Division (SRMD), Geotechnical Laboratory (GL), WES; Mr. W. Milton Myers was Chief, SMB, GL; Dr. Don C. Banks was Chief, SRMD, GL; and Dr. W. F. Marcuson III was Director, GL. Dr. Banks was also the Manager for Technical Area 2, "Material Properties Related to Navigation and Dredging," of the DRP. Mr. E. Clark McNair, Jr., and Dr. Lyndell Z. Hales were Manager and Assistant Manager, respectively, of the DRP, Coastal Engineering Research Center (CERC), WES. Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., were Director and Assistant Director, respectively, of CERC, which oversees the DRP.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

For further information concerning this report, contact
Mr. E. Clark McNair, Jr., (601) 634-2070.

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1 Introduction

This users's guide contains instructions for installing and using GEOSITE (**GEO**technical **SITE** investigation methods), a knowledge-based expert system (KBES). The two diskettes for the Microsoft Windows® version of GEOSITE are included with each copy of the user's guide; a limited number of the MS-DOS® version are available on request to Ms. Gloria Naylor, Scientific and Engineering Applications Center, Information Technology Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180 (CEWES-IM-DS).

Objective of GEOSITE

The objective of GEOSITE is to provide guidance, from geotechnical engineering experts, for the selection of equipment and methods for a subsurface investigation at an individual exploration site for a dredging project. It is assumed that the number and locations of the exploration sites have previously been established and that there is a general knowledge of the types of sediments expected to be present at the site. *Only for the purpose of this program, the term "sediment" is used to mean all bottom materials to be dredged, including unconsolidated sediments (soil) and hard materials (cemented soils, rock, coral, etc.)*

The GEOSITE program recommends: (a) sediment sampling methods, (b) in-situ strength testing methods, considering all of the appropriate sampler/testing method combinations, (c) methods for accessing the sampling/testing depth, (d) suitable field work platforms, and (e) material identification tests. The reasoning for the recommendations is given in "Discussion" texts.

GEOSITE is primarily intended to be used by persons familiar with basic geotechnical site investigation and testing methods, such as a Corps of Engineers civil engineer or engineering geologist. GEOSITE may also be useful to dredging contractors, either for internal use or for use by a private geotechnical firm in their employ.

Two parallel and equal versions of the GEOSITE program have been developed. One operates in the conventional Microsoft Disk Operating System (MS-DOS)® environment and the other runs under the Microsoft Windows® environment. Knowledge databases, control programs, and inferencing mechanisms for both versions are identical. Input and conclusion screen displays

are also identical, except that the screen displays in the MS-DOS version are character-based and in the Microsoft Windows version they are graphics-based.

Both the Windows and the MS-DOS versions are user friendly and support mouse input. Input is provided through a group of consultation screens, each containing a question with multiple choice answers. Answers and/or screen controls are selected by mouse-pointer clicking or by using keyboard arrow keys and keystroke combinations. This eliminates the need for the user to type most words or numbers for data input during guidance sessions. This is intended to accelerate the input process, eliminate typographical errors, and facilitate the use of the system by non-typists. The path through the input screens is not pre-defined; the question asked on each new screen is the result of the specific answer to the question posed on the previous screen(s).

Program Overview

The first step in any geotechnical site investigation is the assembly and evaluation of all prior information about the proposed dredging site. This information is used to develop a tentative geotechnical subsurface profile. Sources of prior information include a review of existing geological and geotechnical data from the vicinity of the project site and may include a geophysical survey of the site. The number and location of exploration sites is selected, based on a number of factors, including site variability. Therefore, at any exploration point where a pit or boring will be made, a general idea of the stratigraphic profile already exists in the mind of the evaluator, even if it is erroneous.

The consultation process of GEOSITE starts with the assumption that the stratification is moderately well known. It is reasonable to require this assumption; this demands that every effort be made to assemble and evaluate the pre-existing information and to use geophysical surveys wherever they are feasible. The choice of specific primary sediment types from the expected profile causes GEOSITE to limit its consultation advice only to those topics that apply to those sediment types and to exclude all others. If, in the field, the profile expectation is found to be wrong, then a return to the program for re-evaluation with the updated information will be necessary. Four separate exploration objectives are provided in GEOSITE:

a. REGULAR (Complete) INVESTIGATION—The selection of sampling and testing methods for in situ strength and material identification properties.

b. LIMITED TO DENSITY TESTING ONLY—The selection of field sampling and testing methods for in-situ density evaluation only.

c. LIMITED TO FINDING ROCK SURFACE ONLY—The selection of methods useful in the search for the surface of a hard layer or rock below soil overburden.

d. LIMITED TO MATERIAL IDENTIFICATION TESTS ONLY—Recommended laboratory and/or field expedient tests for material identification properties. This option is also included as part of the REGULAR INVESTIGATION program.

Regular investigation

The Regular, or Complete, Investigation objective starts with selection of sediment type. This causes GEOSITE to display a screen of all generic sediment samplers and a description of their suitability for that sediment type. One of the samplers is selected and the next screen displays a choice of field or laboratory (or none) strength testing methods. This choice leads to a screen containing strength test methods and their suitability for the combination of sediment type and sampling method. The screen also displays, for each test method, a Confidence Factor and a Utility Factor (defined below). If desired, the contents of this screen may be printed in report form for filing.

If desired, the user may then return to previous screens for advice on a different combination. Or, once a sampler and test method are chosen, further guidance is given for methods to access sampling-testing depth, for field work platforms, and for material identification tests.

Density testing only

The Density Testing Only objective starts with a selection of one of the sediment types expected in the sediment profile. GEOSITE then provides guidance on the suitability of various methods for determining the in-situ density. Most of the methods are different from methods used for sampling and/or strength testing.

Rock surface only

The Rock Surface Only objective starts with selection of the sediment type that forms the overburden for the rock or hard surface to be located. Guidance is then given about the suitability of various methods for locating the surface of rock or a hard layer.

Material identification tests only

This option is available for the user that simply wants guidance on material identification tests that are appropriate for identifying, describing, and possibly classifying a disturbed sample. It is also included as part of the sequence of guidance screens in the "Regular Investigation" objective.

Background

The KBES computer program described herein was developed as part of the USAE Waterways Experiment Station (WES) Dredging Research Program (DRP) Work U: No. 32471, "Descriptors for Bottom Sediments to be Dredged." The objective of the work unit is to develop standard dredging-related geotechnical descriptors for indicating, or inferring, the dredgeability of sediments.

A KBES such as GEOSITE can serve a continuing need in one or another of three situations:

a. As a guide, or computerized mentor, for those persons lacking knowledge and experience in the geotechnical site investigations for dredging projects.

b. As an educational aid in the training of geotechnical engineers and engineering geologists to become involved in dredging project subsurface investigations.

c. For peer review, where knowledgeable and experienced personnel can consult with other experts for review, and as a check on their own work.

Outline of This User's Guide

Chapter 2 gives installation instructions for placing the Windows version and/or the MS-DOS version of GEOSITE on the user's hard disk.

Chapter 3 contains operating instructions for the GEOSITE program. Each of the data selection (input) display and conclusion display screens is discussed and a description of the discussion (help) screen system is presented.

Chapter 4 presents a brief discussion of three background topics for users of the GEOSITE program. First, there is a general discussion of knowledge-based expert systems and the manner in which they function. Second, the rationale for selecting a relational database management system as the expert system development shell is presented. Third, the relationship of a KBES with a printed report is examined.

Chapter 5 discusses potential future modifications to the GEOSITE program. The requested review information is intended primarily for use by the programmers and administrators of the development version of GEOSITE.

2 Installing GEOSITE

There are two equivalent versions of the GEOSITE program: the Windows version and the MS-DOS version. The versions differ only in the format of the display screen files. The Windows version screens are graphics-based and the MS-DOS version displays are character-based . Because of its graphical environment, the Windows version of GEOSITE contains graphics that are not available in the current MS-DOS version. The user may install both versions on the same computer, but in different directories.

(NOTE: DO NOT place the DOS version files in the same directory as the Windows version because they use screen file names in common. This will cause malfunction of the programs.)

Appendix A contains a listing of all files contained on the distribution diskettes for the Windows version and the DOS version of GEOSITE.

System Requirements

Suggested minimum equipment requirements are:

a. 80386SX processor, or higher.

b. Mouse (not absolutely necessary for DOS version, but highly useful).

c. Minimum of 4 MB RAM (preferably 6 for the Windows version).

d. MS-DOS version 3.1 or higher.

e. For the Windows version, Microsoft Windows version 3.1 or higher running in 386 enhanced mode.

f. At least 6 MB of free hard disk space for the Windows version. At least 4 MB of free hard disk space for the DOS version.

g. Standard VGA monitor (640 x 480 pixels). NOTE: The Windows version uses color graphics and the DOS version contains color screens. A monochrome monitor can be used but the images will be displayed in black and white. Other color monitors, such as SVGA, may be used but

display quality may be affected. (If difficulty is encountered, see discussion below.)

Hard Disk Installation—Windows Version

The Windows version of GEOSITE is contained in two 3.5-in. high-density (1.44-MB) diskettes. The following steps should be taken to install the Windows (graphics-based) version of the program on a hard disk:

a. Insert Disk No. 1 of the GEOSITE (Windows version) diskettes in drive A (or drive B).

b. Start Windows (refer to the Microsoft Windows user's manual if necessary) or OS/2. In the **Program Manager** window, click the mouse on **FILE**. In the FILE menu, click the mouse on **RUN**.

c. In the RUN window command line, type **A:\SETUP** (or B:\SETUP); then click on **OK**.

d. The Setup program may take several minutes before the SETUP window appears. The files on the diskettes are compressed and are being decompressed. **Be patient; do not reboot the computer.**

e. When the Setup window is displayed, the user is asked to confirm, or to change, the hard drive letter, the directory name, and the Program Group in which to place the GEOSITE icon. After this choice, Windows continues loading the program, asking for the next disk at the appropriate time.

f. At the completion of the setup (file decompression and loading) process, Windows places an icon marked "GEOSITE" in the chosen Program Group. If you wish to change the icon, refer to the Windows manual for instructions.

Possible Video Problem—Windows Version

The Windows version of GEOSITE was developed, using FoxPro for Windows, on a personal computer with a true VGA video graphics card (640 × 480 pixels resolution and 256 colors). Some computers, such as Gateway 2000 and Dell, use proprietary video graphics cards capable of displaying various resolutions and numbers of colors. Those computers may not function properly when large size graphics are displayed by FoxPro and may terminate the application with an error message.

If you are experiencing video display problems with this program, there are two ways to correct this problem. One way is to contact your computer vendor

for advice and/or to obtain an appropriate graphics driver (*.DRV) suitable for FoxPro for Windows.

As an alternative, you may create a special SYSTEM.FOX file to temporarily replace the SYSTEM.INI file:

a. From the Windows Program Manager window, click on "Widows Setup." If the Display line shows: "VGA," close the window and contact your computer vendor `omputer services department for advice.

b. If the Display line shows other than VGA, close "Windows Setup." Using the File Manager in Windows, copy the file "SYSTEM.INI" as "SYSTEM.BAK."

c. Then, open "Windows Setup" again. Click on "Options; Change Windows Settings; Display," and select "VGA." Confirm this as the "Current" driver and then click on "Restart Windows" in the next window. This creates a new SYSTEM.INI file with VGA as the default video display.

d. Run GEOSITE again. If the problem still exists, contact your computer vendor or computer services department for advice.

e. If this solves the video problem (you can now view large graphics in GEOSITE), run the program. After completion, go to the Windows directory in DOS or use the File Manager in Windows, and rename "SYSTEM.INI" as "SYSTEM.FOX." Then rename "SYSTEM.BAK" as "SYSTEM.INI" and restart Windows. This step will reset your Windows program to its original video environment.

f. Thereafter, any time you want to run GEOSITE, rename "SYSTEM.INI" as "SYSTEM.BAK." Then rename "SYSTEM.FOX" as "SYSTEM.INI" and restart Windows. At completion, reverse the process (as in item *e* above) to reset your system.

Hard Disk Installation—DOS Version

The DOS version of GEOSITE is contained in a 3.5-in. high-capacity (1.44-MB) diskette. To install the program on drive d: (where d: is any desired hard drive) and the directory d:\GEOSITE, insert the DOS disk in drive A (or drive B) and type **A:INSTALL a d** (or B:INSTALL a d), where **d** is the target drive and **a** is the source drive. Type the command exactly as shown; do not use a colon (:) after the target or the source drive names. The installation batch file performs the following tasks automatically. If the batch file does not function properly, then the following operations can be done manually:

a. Create a directory named **d:\GEOSITE** (*d* is the target hard drive; you may use any other unique directory name). Copy all files from the

GEOSITE DOS-version diskette, to the new hard disk directory. The files are in a compressed (archived) format.

b. For example, to install files from disk drive A: to hard disk C: in directory C:\GEOSITE, type the following in order:

C:	(makes C:\ the default drive)
md\GEOSITE	(creates new directory)
cd\GEOSITE	(moves to new directory)

The new default drive is now C:\GEOSITE. Place DOS version diskette in Drive A: and enter

Copy A:*.*	(Copy all files on A to C:\GEOSITE)

c. Decompress (unarchive) the files. To unarchive, remain in the d:\GEOSITE sub-directory and type, in turn:

ARCE FOXDISTR	(FOXDISTR.ARC contains the FoxPro Distribution Kit operating files) and then
ARCE DOSSITE	(DOSSITE.ARC contains all of the GEOSITE files)

d. From within the d:\GEOSITE directory, delete the FOXDISTR.ARC, DOSSITE.ARC, and ARCE.COM files from your hard disk; they are no longer needed! Do this by typing:

DEL ARCE.COM	(Deletes ARCE.COM)
DEL FOXDISTR.ARC	(Deletes FOXDISTR.ARC)
DEL DOSSITE.ARC	(Deletes DOSSITE.ARC)

READ.ME and MANUAL Files

The Windows diskettes and the DOS diskette also contain a READ.ME file, a MANUAL.TXT, and a MANUAL.BAT file. These files are provided as a convenience to the user in the event this User's Guide is not available. The READ.ME file contains on-disk instructions for installation and operation of GEOSITE and for printing the on-disk manual using the MANUAL.BAT file. The manual is an ASCII version (no graphics) of Chapters 1, 2, 3, and 5 of this User's Guide. If not needed for reference, these files may be deleted from the hard disk.

3 Operating the GEOSITE Program

To start the GEOSITE program in the directory d:\GEOSITE (where d: is the installation hard drive):

a. **For the Windows version,** two choices are available:

1. While in the Windows Program Manager window, simply click on the "GEOSITE" icon; or

2. While in the Windows Program Manager window, open (click on) the File menu. In the File menu, click on **RUN.** The RUN command screen will appear. On the Run Command Line, type

   d:\GEOSITE\GEOSITE

   or use the Browse button to locate the GEOSITE.EXE file.

b. **For the DOS version,** move to the d:\GEOSITE directory. From the previous example, assume the GEOSITE program files are in the C:\GEOSITE directory, and type:

   GEOSITE

   This activates a batch file that contains the necessary commands to start the GEOSITE program.

Navigating the GEOSITE Program

The following semi-tutorial presentation discusses the various input and conclusion screens contained in GEOSITE. The figures contain captured copies of Windows version graphical screens. The character-based DOS screens contain the same information, pose the same questions, and contain the same data-option choices, but do not have the Windows graphics effects and fonts. However, navigation of both versions is exactly the same unless specifically mentioned.

The user interfaces with GEOSITE through a series of display screens. Three groups of screens are used:

a. Introductory Displays. The Introductory Displays consist of the Title Display, the Navigation Display, the Purpose Display, the Disclaimer Display, the Scope Display, and the Regular Investigation Flow Diagram Display.

b. Input/Conclusions Displays.

c. Explanation Text (Discussion) Displays.

Display screen features

Each display screen contains one or two sets of control buttons. A button is activated by:

a. Using a mouse to click on a push button or to select a button from a radio button group, or

b. Using the keyboard arrow keys and / or the < **TAB** > key to highlight the preferred button and pressing < **ENTER** >.

Where options are presented for the user's choice of input data, activation of a **data-option** button causes GEOSITE to acknowledge this as the user's choice and proceed to the next display screen. The bottom panel of each screen contains from one to four of the following buttons, as needed, to alter the normal flow of questions and conclusions:

a. < **BACK** > or < **RESTART** > causes the program to return to an earlier display.

b. < **NEXT** > is used to continue the program when data-option activation buttons are not present.

c. < **DISCUSSION** > causes a temporary halt in the program and the display of the Discussion Topics screen (see discussion of this topic at the end of this part of the report). Clicking on the upper left corner of the screen, or using the < **ESCAPE** > key, will return control to the program.

d. < **PRINT REPORT** > (on the Testing Methods Screen only) causes the program to print a report containing the information shown on that screen.

e. < **QUIT** > causes the program to terminate. May be used at any time to return to Windows or DOS.

Title and Navigation screens

The first screen to appear is the Title screen, providing two choices in the control bar at the bottom. For one or more runs, the user may choose to view the Introductory screens described above by activating the **< INTRODUCTORY SCREENS >** button. These are followed by the Objective Screen.

As the user becomes familiar with the program, the introductory displays can be bypassed by activating the button marked **< QUICK START >**. This choice bypasses the Introductory screens and leads directly to the Objective Screen.

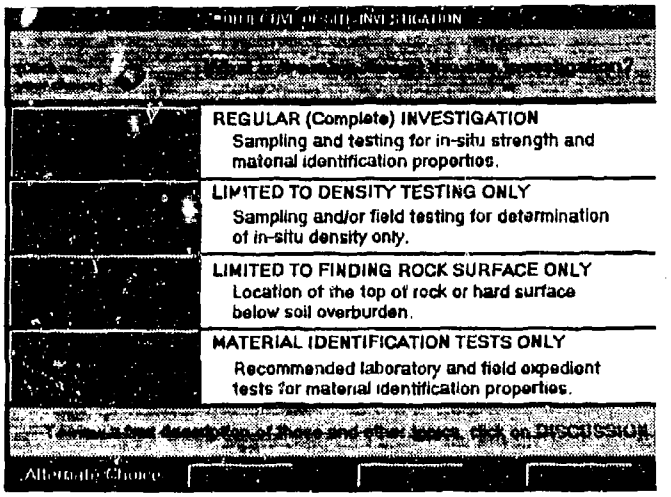

Figure 1. Choice of objective for the GEOSITE guidance session

Objective screen

The Objective screen, Figure 1, lists the possible objectives of the GEOSITE guidance program. The user selects from:

a. REGULAR (Complete) INVESTIGATION—The selection of sampling and testing methods for in situ strength and material identification properties.

b. LIMITED TO DENSITY TESTING ONLY—The selection of field sampling and testing methods for in-situ density only.

c. LIMITED TO FINDING ROCK SURFACE ONLY—The selection of methods useful in the search for the surface of a hard layer or rock below soil overburden.

d. LIMITED TO MATERIAL IDENTIFICATION TESTS ONLY—Recommended laboratory and/or field expedient tests for material identification properties.

Each choice on the Objective Screen leads to the Sediment Type Screen. After that, GEOSITE proceeds to the appropriate screen(s) for the chosen objective.

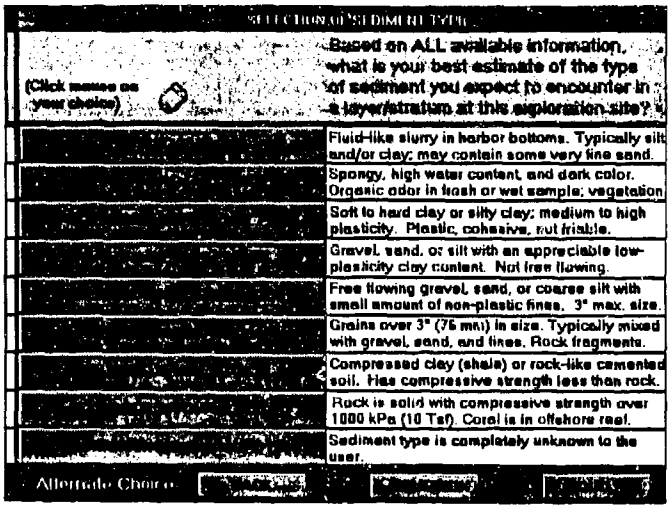

Figure 2. Sediment type selection screen

Sediment type screen

In addition to an objective, GEOSITE also must know the type of sediment to be expected. This information must come from a literature search or "desk study," i.e., the research of all existing (prior) geological and geotechnical information about the site. This research may be supplemented with geophysical studies of the site. GEOSITE is limited to one sediment type per guidance session. If more than one sediment type is expected to be present, each deposit must be evaluated separately and the recommendations combined into a coherent plan for that site. This may require several runs with the trial of various options until the most desirable selection is found. It is recommended, in this case, that the results of each case be printed (see report print option below), as GEOSITE does not keep track of successive trials.

The knowledge base for all objectives is restricted to the following six sediment types and UNKNOWN, as shown on Figure 2:

a. Fluid Mud.

b. Highly Organic Soil.

c. Cohesive (Clayey) Soil.

d. Friable Mixed-Grain Soil.

e. Cohesionless (Coarse) Soil.

f. Boulders and Cobbles.

g. Shale or Cemented Soil .

h. Rock or Coral.

i. UNKNOWN.

If UNKNOWN is chosen, GEOSITE displays a message directing the user to obtain more complete information before continuing.

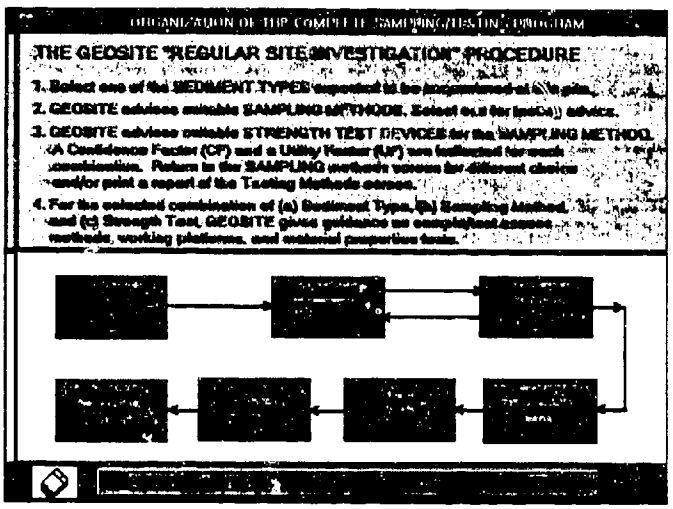

Figure 3. Flow diagram of GEOSITE complete investigation program

Regular (Complete) Investigation Displays

The conduct of a Regular (Complete) Site Investigation guidance session follows the flow diagram shown in Figure 3, which is a copy of the Complete Investigation Screen, one of the Preliminary Screens.

Sampling display

For the selected sediment type, the SAMPLING knowledge base is queried for the suitability of each of a fixed list of eight samplers in the Sampling Query, and the rule statement is:

IF the sediment type is:
THEN the suitability of the . . . (each of the following) . . .
SAMPLING method is:

The eight generic sampler types used in the current version of GEOSITE are:

a. Thin Wall Tube Sampler, Undisturbed.

b. Core Barrel Sampler, Undisturbed.

c. Split-tube Drive Sampler, Disturbed.

d. Vibrating Tube Sampler, Disturbed.

e. Gravity Projectile Sampler, Disturbed.

f. Bucket Auger Sampler, Disturbed.

g. Surface Grab Sampler, Disturbed.

h. Powered Scoop Sampler, Disturbed.

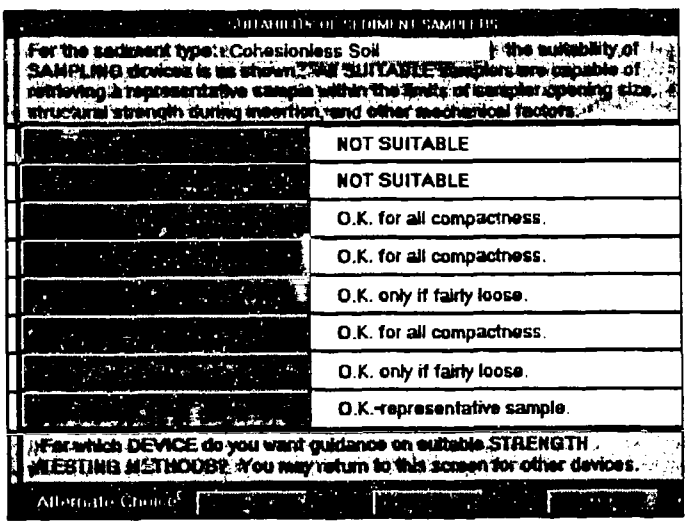

Figure 4. Sampler suitability screen

The results are shown on the SUITABILITY OF SEDIMENT SAMPLERS screen, Figure 4, that displays each sampler name and its suitability for the selected sediment type. Perhaps all of the sampling methods are suitable, or perhaps some are not, depending on the selected sediment type. The suitability of each is given in a short message to the right of the sampler name. The unsuitable ones are marked "NOT SUITABLE." Further discussion of the various samplers is given in the "Discussion" screens. The user selects one of the samplers for guidance in suitable strength testing methods to accompany the chosen sampling method. In the unique case of Fluid Mud, one special screen displays the sampling method and strength testing methods suitable for that consistency and composition of material.

Testing display

For each combination of sediment type and sampling method, the TESTING knowledge base is queried for the suitability of each of a fixed list of 18 strength testing methods in the Testing Query, resulting in the following rule statement:

IF	the sediment type is:
AND	the sampling method is:
THEN	the suitability, confidence factor, and utility factor of the . . . (each of the following) . . . STRENGTH TEST method are:

Test type screen

Because of space limitations on the screens, the strength test methods have been sub-divided into three groups, each shown on a separate, but similar, conclusions display. The user's choice is made on the Test Type Screen, Figure 5.

Confidence and utility factors

No attempt is made on the testing guidance screens to recommend one method over another. However, two judgement factors, based on the developers' personal experience, are given for each test method: a confidence factor and a utility factor. A *Confidence Factor* is defined as the relative accuracy and precision of a strength testing method compared to the other methods in the group. A *Utility Factor* is defined as the relative efficiency of a testing device in terms of time and money cost, including difficulty of mobilization of equipment at the site, time for making a test, complexity of test method, and need for securing a sample using a different device. The factors range from zero to 10, with 0 being lowest and 10 being highest.

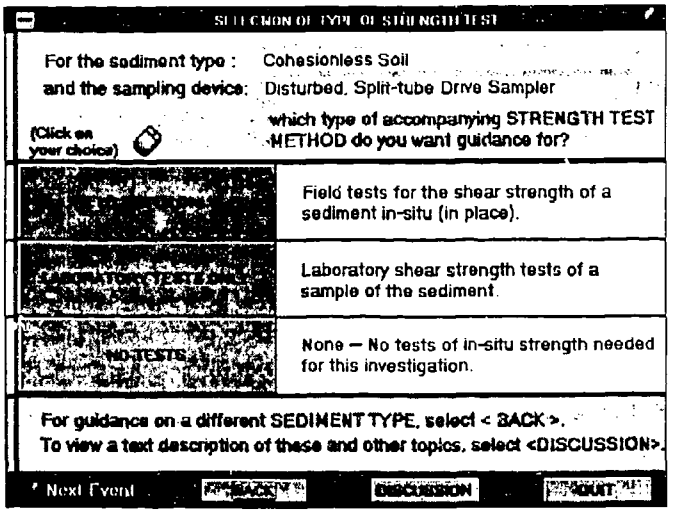

Figure 5. Selection of strength test type

Soils field strength tests

If, on Figure 5, the Field Strength Tests choice is made, the Field Test Methods Display is shown, as in Figure 6. Those that are not appropriate are marked "NOT SUITABLE." The eight strength test methods used in this version of GEOSITE and included on that screen are:

a. Standard Penetration Test (SPT).

b. Static Cone Penetration Test (CPT).

c. Vane Shear Test (VST) of Cohesive Soil.

d. Dynamic Penetrometer Test, Thick Wall Tube.

e. Dynamic Penetrometer Test, Solid Cone.

f. Penetration Rate of Vibrating Tube Corer.

g. Deceleration Rate of Gravity Projectile.

h. Hand-held Sounding Rod Test.

Soils laboratory strength tests

If the Laboratory Tests choice is made on the screen of Figure 5, the Laboratory Strength Test Methods Display is shown, Figure 7. Those that are not appropriate are marked "NOT SUITABLE." If any of these is selected, an

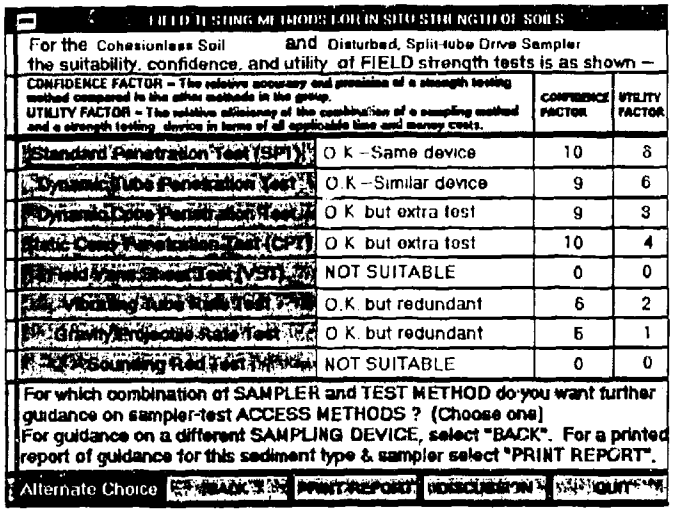

Figure 6. Field strength test suitability screen

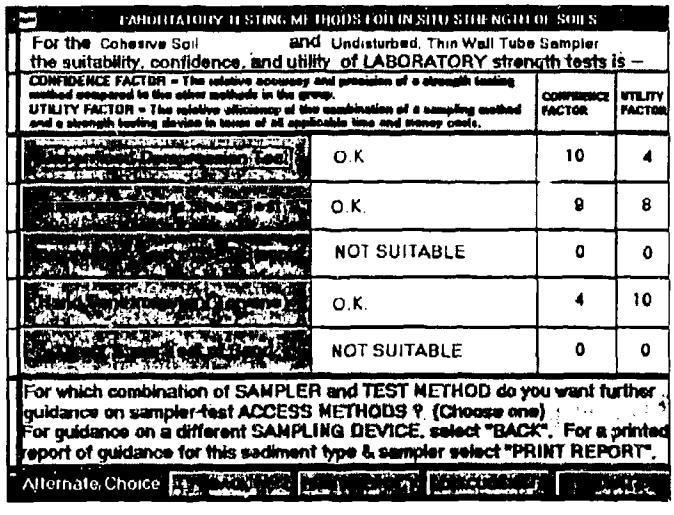

Figure 7. Laboratory strength test suitability screen

error message appears. The five strength test methods used in GEOSITE and included on that screen are:

a. Compression Test of Undisturbed Cohesive Sample.

b. Vane Shear Test of Cohesive Sample.

c. Compression Test of Thick Wall Tube Cohesive Sample.

d. Hand Penetrometer/Torvane Test of Cohesive Sample.

e. Direct Shear Test of Re-densified Sand Sample.

Rock strength tests

If the Rock Strength Tests choice is made on the screen of Figure 5, the Rock Test Methods Display is shown, Figure 8. Those that are not appropriate are marked "NOT SUITABLE." If any these is selected, an error message appears. The five strength test methods used in GEOSITE and included on that screen are:

a. Laboratory, Unconfined Compression Test of Rock Core.

b. Laboratory, Splitting Tensile Test of Rock Core.

c. Laboratory/Field, Point Load Test of Rock Core.

d. Field, Diver Operated Rebound Hammer Test of Rock.

e. Field, Drilling Parameter Recorder Test (DPR).

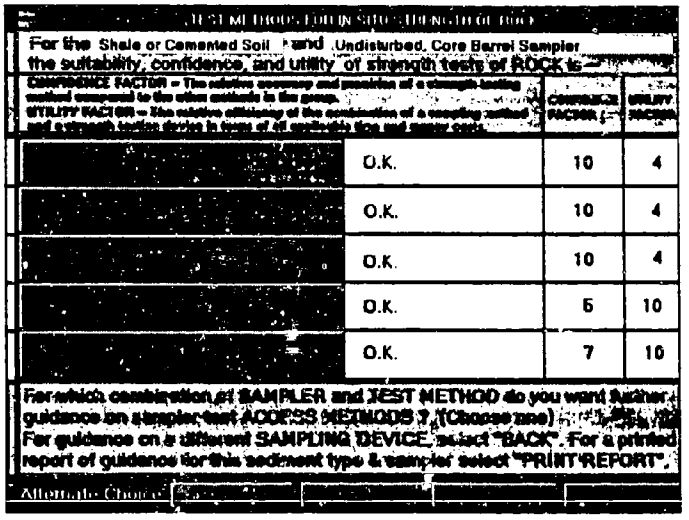

Figure 8. Rock strength test suitability screen

Further testing guidance

From any of the Strength Testing Methods displays, the user can select one of three courses of action:

a. Use < **BACK** > to return to the Sediment Type Display, the Sampling Display, or the Test Type Display to choose a different set of antecedents (different IF-AND- statement);

b. Use < **PRINT REPORT** > to print a report of the contents of all of the current Testing Methods screens; or

c. Select one of the suitable testing methods and move on to guidance about suitable methods for accessing the sampling and testing depth.

Print report display

If a printed report of the Test Method conclusions is desired, press the < **PRINT REPORT** > button. This causes the screen of Figure 9 to appear. That screen requests optional input of the user's name, organization, and project to appear on the printout. It also lists the current choice of Sediment Type and Sampler. Pressing the < **PRINT** > button on the Print Report screen then causes a printout of ALL testing method conclusions for those antecedents, i.e., the Field Tests, the Laboratory Tests, and the Rock Tests. After the printing, the user is returned to the calling Strength Test screen. (**NOTE:** Printing in the Windows version of GEOSITE is controlled by the Windows "Print Manager." In the DOS version, GEOSITE directs the print command to the default printer. For troubleshooting, refer to the Windows or DOS manuals, as appropriate.)

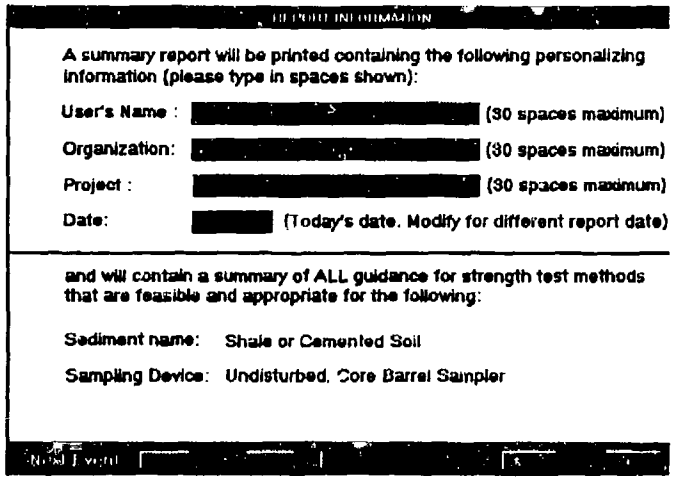

Figure 9. Report information input screen

Access methods display

For any chosen combination of sediment type, sampling method, and strength testing method, each of six general methods of accessing (reaching) the sampling and/or testing depth is evaluated in the ACCESS knowledge base using the Access Query, resulting in the following rule statement:

IF	the sediment type is:
AND	the sampling method is:
AND	the strength testing method is:
THEN	the suitability of the . . . (each of the following) . . . method of ACCESSING (reaching) the sampling / testing depth is:

The generic types of sampling/testing depth access methods used in this version of GEOSITE and used in the Access Query are:

a. Surface Sample or Test.

b. Machine Dug Pit or Trench.

c. Cased Boring, Machine Operated.

d. Cased Boring, Hand Operated.

e. Hollow Stem Auger, Machine Operated.

f. Self-Penetrating Sampling/Testing Device.

The suitability of each of the six access methods is shown on the METHODS FOR ACCESSING SAMPLING AND TESTING DEPTH screen, Figure 10. There is a group of test methods, listed in Testing Query above, that includes devices that are self-penetrating, i.e., for which no boring or pit is needed. Their suitability is grouped under the general heading of Self-Penetrating Sampling/ Testing Devices.

After viewing the guidance on access methods, the user chooses one of the access methods for guidance on suitable fieldwork platforms. First, however, the user is asked about expected water conditions at the exploration site.

Water conditions display

Evaluation of work platform suitability involves consideration of the water roughness and current velocity. These are selected from among the choices given on the WATER CONDITIONS AT THE SITE screen, Figure 11. Water depth was not considered a significant factor because, at present, dredging site investigations are rarely done in water over 15 m (50 ft) deep.

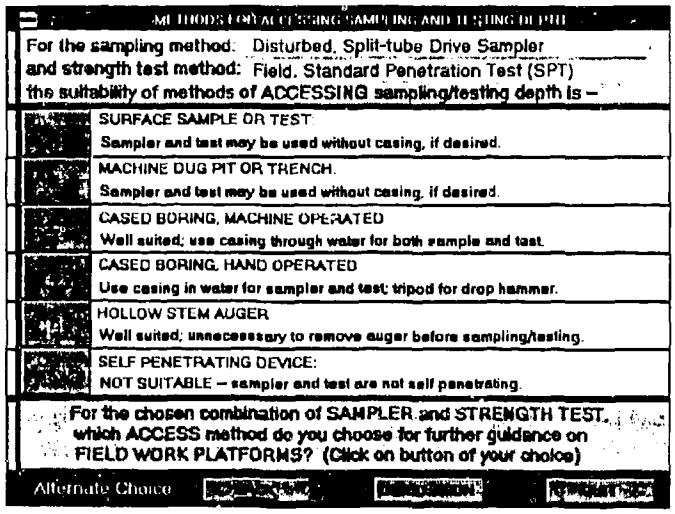

Figure 10. Suitability of methods for accessing testing depth

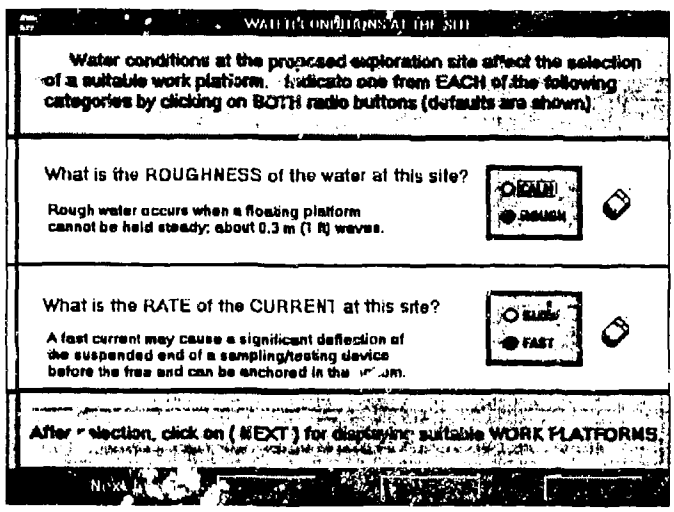

Figure 11. Subsurface water conditions screen

Platforms display

After election of any of the suitable sampling and / or testing access methods, GEOSITE determines the suitability of field work platforms from the PLATFORM knowledge base using the Platform Query, with the rule:

IF the method of accessing sampling or testing depth is:
AND the water roughness is: (Calm, Rough)

AND and the current speed is: (Slow, Fast)
THEN the suitability of the . . . (each of the following) . . . type of FIELDWORK PLATFORM is:

The types of field work platforms considered in the Platform Query in this version of GEOSITE are:

a. Bottom (Spud) Supported Surface Platform.

b. Bottom Supported Submersible Platform.

c. Ship, With Swell Compensating Devices.

d. Small Boat or Barge.

e. Diver, Operating From Surface Vessel.

Guidance concerning these platforms is shown on the SUITABILITY OF PLATFORMS FOR SAMPLING AND FIELD TESTING screen, Figure 12. After viewing that screen, the user may choose to go to the **< NEXT >** guidance display, the materials tests screen.

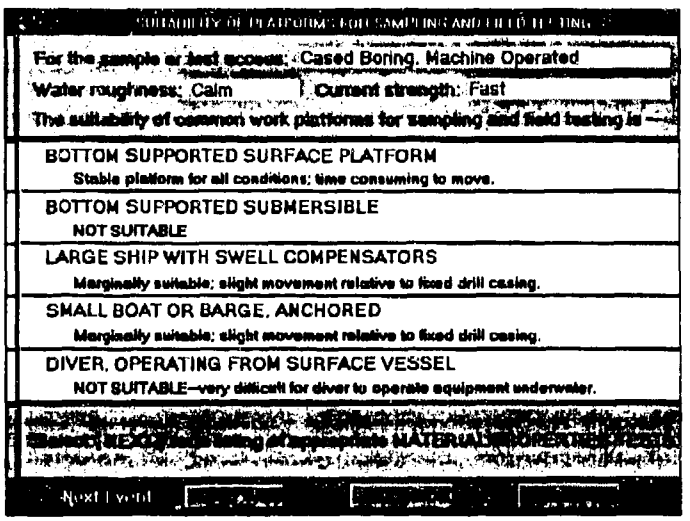

Figure 12. Suitability of work platforms screen

Materials tests display

As the final guidance screen in the Regular Investigation series, the selected sediment type is used to query the MATTEST (materials testing) knowledge base using the Mattest Query, with the rule statement:

IF the sediment type is:
THEN the suitability of the . . . (each of the following) . . .
MATERIALS IDENTIFICATION TEST is:

The suitability of each of the following eight common, standardized methods for determining the identification properties of a sediment is shown on the APPROPRIATE MATERIALS IDENTIFICATION TESTS screen, Figure 13.

a. Coarse grain sizes (mechanical sieve analysis).

b. Fine grain sizes (hydrometer, decantation, pipette).

c. Atterberg limits.

d. Ash content test for organics.

e. Water content.

f. Specific gravity of grains.

g. Visual-Manual granular soil tests.

h. Visual-Manual cohesive soil tests.

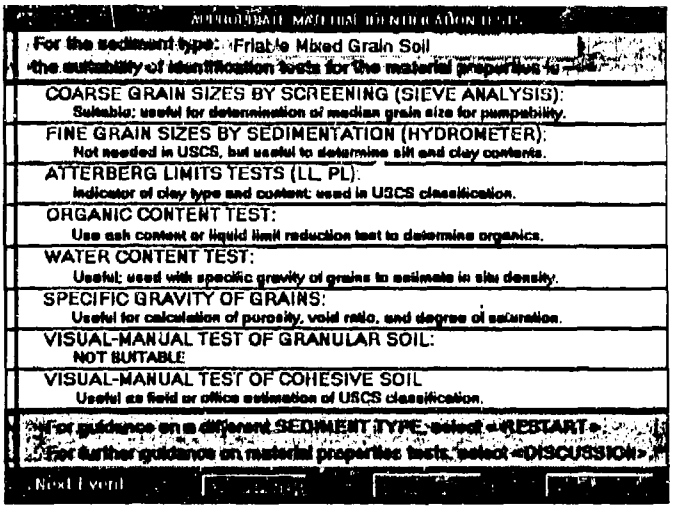

Figure 13. Suitability of material identification tests screen

This completes the guidance for a chosen combination of sediment type, test method, sampling method, and access method for the "Regular (Complete) Investigation."

Density Display

If the LIMITED TO DENSITY TESTING ONLY objective is chosen and a specific sediment type is selected, the DENSITY knowledge base is queried for the suitability, for that sediment type, of each of six methods, as shown in the Density Query, and the rule statement is:

IF the sediment type is:
THEN the suitability of the . . . (each of the following) . . . FIELD DENSITY TEST method is:

GEOSITE, in its present version, evaluates the sediment type and the suitability of each of the following methods is shown on the METHODS FOR MEASURING IN-SITU DENSITY screen, Figure 14:

a. Field, Geophysical Acoustic Impedance.

b. Field, Static Nuclear Gauge Probe.

c. Field, Towed Nuclear Gauge.

d. Laboratory, Undisturbed Tube Sample.

e. Laboratory, Drilled Rock Core.

f. Laboratory, Resuspended Density of Sand.

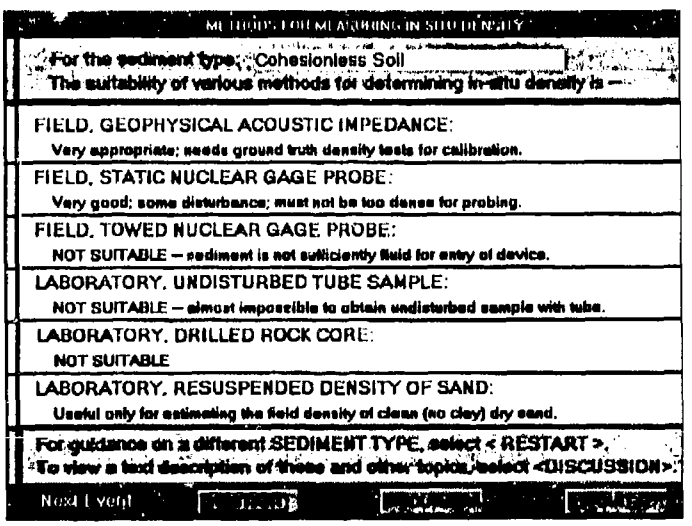

Figure 14. Field density test methods screen

Rock Surface Display

If the LIMITED TO FINDING ROCK SURFACE ONLY objective is chosen and a specific sediment type is selected, the ROCKSURF knowledge base is queried for the suitability, for that sediment type, of each of five methods using the Rock Surface Query, using the following rule statement:

IF the sediment type is:
THEN the suitability of the . . . (each of the following) . . . method for locating the SURFACE OF ROCK OR A HARD SOIL is:

GEOSITE evaluates the sediment type and displays the suitability of each of the following five exploration methods on the METHODS FOR LOCATING ROCK SURFACE screen, Figure 15:

a. Geophysical—Acoustic Impedance, Seismic, or Equivalent.

b. Dynamic Penetrometer—SPT, Thick Wall Tube, Solid Cone, or Similar.

c. Static Penetrometer—CPT or Similar.

d. Hand-Held Sounding Rod, Water Jet, or Similar.

e. Penetration Rate of Vibrating Tube Corer or Similar.

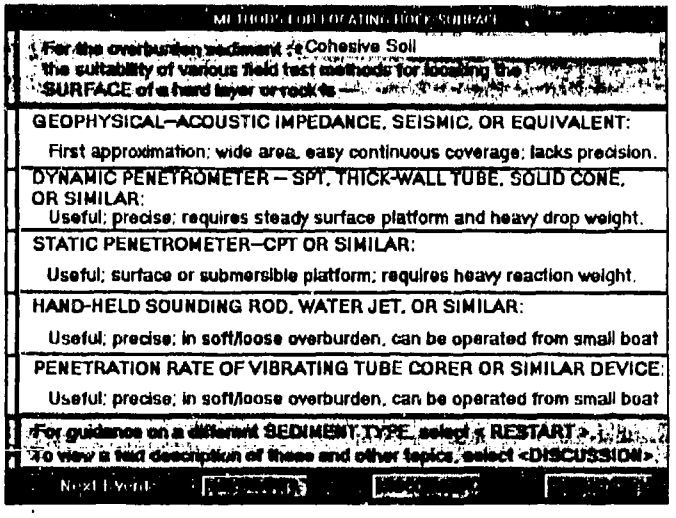

Figure 15. Finding rock surface methods screen

Discussion Facility

Activation of the < **DISCUSSION** > button at the bottom of any of the displays causes the control program to display a menu of explanatory texts that pertain to site investigations for dredging projects. Each text is intended to present a discussion of the antecedents (IF-statement) or an explanation of the conclusions (THEN-statement) and rules used in the knowledge bases. Care is taken to differentiate between factual information and the experts' interpretation(s) of the facts.

Because of the differences between the Windows graphical environment and the DOS character-based environment, two formats of the DISCUSSION facility are used. The text portion of both formats is identical. However, the Microsoft Windows version includes graphic line drawings and pictures that are not possible in the DOS version. The topics included in both discussion facilities of the present version of GEOSITE are listed in Table B-1, in Appendix B.

Windows-style discussion facility

The Windows version discussion topics are displayed in the Windows format help facility database titled SITEHELP.HLP. The Main Menu is first displayed, showing the major topic headings in **green** (or the default color of the HELP facility in your Windows setup). By clicking the mouse pointer on any of the major topics, a Sub-Menu for that topic is displayed. Clicking on any of these **green** colored topics will display the text and graphics of that topic.

Three control buttons at the top of the screen are used by Windows. The < **BACK** > button will cause a return to the previous screen. The Main Menu is accessed at any time by choosing the < **CONTENTS** > button. Clicking on the button marked < **HISTORY** > displays a record of all screens viewed during a "help" session.

There are two ways to EXIT the discussion facility. First, by either double-clicking on the (--) button at the upper left corner of the screen or by single-clicking the button and choosing "Close." The second method involves clicking on the word "File" in the Menu Bar, and then choosing "Exit."

The contents of any of the topics can be printed by clicking on the word "File" in the Menu Bar. Click on the menu choice of "Print Topic."

DOS-style discussion facility

The DOS character-based discussion topics are contained in a Microsoft FoxPro 2.5 database titled SITEHELP.DBF. The format of the database of discussion topics is that dictated by the internal format of the FoxPro Help Facility. Clicking on "Topics" causes a display of the topics in the facility. The text of any topic can then be displayed by clicking on the topic name or by

highlighting the topic name using a cursor and then pressing < **ENTER** >. The Discussion Facility may be exited by clicking on the upper left corner of the screen or by pressing the < **ESC** > button on the keyboard.

Topics available in the GEOSITE discussion facility

The topics included in both the GEOSITE Windows version and DOS version discussion facilities are given in Appendix B, Tables B-1 through B-9. Table B-1 is the Main Menu and the following tables are the Sub-Menus.

4 The GEOSITE Programming Environment

This part of the Users's Guide contains background information used in the development of the GEOSITE program. Topics discussed are: (1) knowledge-based expert systems in general, and (2) the reasons for selection of the Microsoft FoxPro operating environment as an expert system shell.

Knowledge-Based Expert Systems

A Knowledge-Based Expert System (KBES) uses expert-derived rules for its solutions. The rules can incorporate and process judgement, experience, empirical rules of thumb, intuition, and other expertise as well as proven functional relationships and experimental evidence. During a guidance session, a KBES such as GEOSITE searches its knowledge bases through a chain of IF - THEN rule statements. The logic of the arguments of the IF-statements may be either English words or phrases or numbers. The path through the matrix of rules is not pre-determined; rather, the path depends on the specific questions and on the user's replies, each of which lead to the next question and the next list of possible replies.

In the KBES form used in GEOSITE, the program asks one or more prerequisite IF-questions, after which the answer(s) are used to select and search the correct knowledge base for the appropriate THEN-solution or group of solutions. Then, another one or more questions are asked and the answer(s) again are used to select and search another appropriate knowledge base. This questioning, selecting, and searching process continues until all of the pertinent questions have been answered or the user chooses to quit.

Expert systems generally contain a group of independent, but interrelated, components as shown on Figure 16. The User Interface interacts with the User, employing an on-screen dialog for communication. When available, an on-screen "Help Memo" provides helpful information for making selections. Screens are also used to display the conclusions reached by the program. The Control Program and Inference Engine unit contains the control information that directs the flow of questions and conclusions. The program provides for interaction between the User Interface and the Antecedent (Context) Memory.

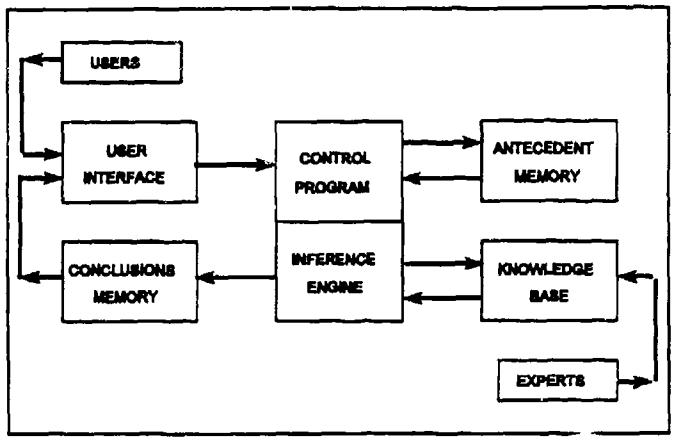

Figure 16. Components of a knowledge-based expert system

The Control Program-Inference Engine mechanism is independent of the knowledge base, permitting modifications and additions to the conclusions contained in the knowledge base without modifying the program. The Antecedent Memory, often called the Context, is a temporary memory containing the current answers to questions. The words, phrases, or numbers in Context must be standardized terms to match those in the knowledge base. The Knowledge Base contains all of the IF-THEN rules that are queried by the Inference Engine using the Antecedents stored in Context. The rules satisfying all of the antecedents are stored in Conclusions Memory, available for display on one or more Conclusion Displays at the User Interface.

Selection of the Programming Environment

GEOSITE uses a forward-chaining, or data-driven, problem-solving strategy. The knowledge representation is rule-based, each rule consisting of an "IF-AND-antecedents . . . THEN-conclusion" statement. One rule exists for each of the total, finite number of options in the antecedents.

In the present version of GEOSITE, there are 3,780 rules in the 7 knowledge bases. Ideally, each unique set of antecedent options leads to a single conclusion. In the SAMPLING knowledge base, GEOSITE reaches 9 conclusions (one for each generic sampler type) for each of 8 sediment types, for a total of 72 rules. For each of the 18 generic strength test methods in the TESTING knowledge base, GEOSITE reaches 3 conclusions (suitability, confidence factor, and utility factor), for a total of 54 conclusions for each combination of sediment type and suitable sampler, resulting in 2,754 rules. There are 582 rules in the ACCESS knowledge base, with 6 conclusions for each of 97 combinations of sampling device and testing method. There are 220 rules in the PLATFORM knowledge base, with 5 conclusions for each of 44 combinations of sampler/test method, water roughness, and current strength. The MATTEST knowledge base contains 64 rules, for 8 sediment types and

The MATTEST knowledge base contains 64 rules, for 8 sediment types and 8 conclusion fields. In the DENSITY knowledge base, there are 48 rules, with 6 conclusions for each of 8 sediment types. And the ROCKSURF knowledge base contains 40 rules, 1 for each of 8 overburden sediment types with 5 conclusions for each.

The programming environment chosen for the development of GEOSITE was the Microsoft FoxPro Relational Database Management System, a product of the Microsoft Corporation, Redmond, Washington. FoxPro offers several desirable features:

a. FoxPro is a cross-platform application, permitting the user a choice of either the MS-DOS or the popular Windows environment. FoxPro 2.5 for MS-DOS and FoxPro 1.0 for Windows are parallel systems, sharing control programs and databases. Display screens are also useable in either environment, although the graphical screens of Windows can use enhancements not available in MS-DOS displays.

b. The software vendor, Microsoft Corporation, is a large, secure company that is expected to be available for help and for future upgrades of the system. The Microsoft Disk Operating System (MS-DOS) and Microsoft Windows are from the same company, ensuring cross-platform compatibility.

c. Knowledge can be represented in a database format (.DBF). The format used in FoxPro is compatible with the Borland dBase III and dBase IV databases. FoxPro can also import files from other popular software packages such as Framework II, Microsoft Multiplan, Borland Paradox, Lotus/Symphony and compatible spreadsheets, and Microsoft Excel. Any of these programs can then be used to access, and to modify, the knowledge bases (databases) in GEOSITE.

d. FoxPro contains a number of useful development aids, such as a screen development program, standard Xbase database programming, and a transporter program for converting, if desired, between MS-DOS and Windows screens.

e. Run-time versions of the programs (DOS and Windows) are distributed to users with the Microsoft FoxPro Distribution Kit for DOS and the Microsoft FoxPro Distribution Kit for Windows. A one-time fee for each Distribution Kit permits an unlimited number of distribution copies.

Even though GEOSITE was developed using a database management package, Microsoft FoxPro 2.5, it is still considered a KBES. The databases used in the inferencing contain subjective expert information compiled by the developers. Conclusions are reached using an inference mechanism and IF - THEN rules similar to any other expert system. In addition, GEOSITE is highly interactive, user friendly, and contains an on-line help facility, which are all essential features of a KBES.

Relationship to Published Reports

A KBES is, in effect, a technical report that has been placed into a computerized question-and-answer format. All of the information could, alternatively, have been contained in a written and published report. However, a computer-based KBES has certain advantages over the printed document:

a. The sequence of questions is expert-guided for each specific task. The user provides answers to the questions from an exhaustive, but limited, set of correctly phrased answers, using standard terminology. When all necessary questions have been asked, and answered, the appropriate knowledge base is searched for all valid conclusions that can be derived from the problem context. The conclusions are presented on screen and, in some instances, can be printed.

b. It is simpler, easier, and faster to use than a published report. Pages appear on screen quickly rather than requiring hunting for the contents or index, then searching for the exact page, or pages.

c. The knowledge recorded in the knowledge base can be easily edited and modified to accommodate new research findings or local experiences, permitting the issuance of easily-made upgrade versions of GEOSITE on microcomputer diskettes. The text information contained in the readily-accessible "Discussion" topics can also be easily added to or changed. This does not imply that the user will be able to modify the control program or the knowledge base directly. Only the official, development version under the control of the developers or the program administrators will be capable of being modified.

5 Modifying and Upgrading GEOSITE

Knowledge-Based Expert System programs such as GEOSITE have no completion point; there is always more knowledge that can be added and there are more conclusions that can be drawn. The program details that are presented here are intended for use in the preparation of future upgraded versions of this program.

The program diskettes accompanying this User's Guide are read-only, i.e., any changes entered onto the display screens during a guidance session cannot be stored. The original, development version of the program can only be modified by using the Microsoft FoxPro 2.5 Relational Database Management System. The original program diskettes reside with the Manager, Dredging Operations Technical Support, USAE Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

The rules developed for GEOSITE represent knowledge and expertise that were developed through professional experiences and research studies and, therefore, reflect the personal biases of the developers. It is most desirable that the present rules be critically reviewed by other geotechnical engineering and dredging experts and expanded or modified, as needed. In the ideal knowledge base, there are multiple experts to either reinforce each other or present valid alternate solutions to problems.

It is requested that users evaluate the program's usefulness, the screens, and the conclusions. There are many questions that can be asked by the developers. With the conclusions that are stored in the Conclusions Memory after a query, are there any other conclusion displays that would be meaningful? Are there any other conclusions that should be drawn from the antecedents? Is the information contained in the Conclusion Displays sufficiently complete that the user can understand and then utilize the guidance correctly? Are the program and the displays user-friendly? What else can, or should, be done to improve the usefulness of the GEOSITE program? The proposed changes should be sent to the Manager, Dredging Operations Technical Support at the address given above.

Appendix A
Files Contained in the GEOSITE Distribution Diskettes

The following listing shows all of the files contained on the distribution diskettes for GEOSITE. If any of these files are missing or corrupted on your diskette, please contact the Manager, Dredging Operations Technical Support at the USAE Waterways Experiment Station, Vicksburg, MS.

DOS Version of GEOSITE

DOSSITE.ARC	All of the GEOSITE program files.
FOXDISTR.ARC	All of the FoxPro files needed to run program.
GEOSITE.BAT	Provides automatic running of the installed program.
INSTALL.BAT	Provides automatic installation from a diskette.
MANUAL.BAT	Provides automatic printing of the on-disk manual.
ARCE.COM	Uncompresses the *.ARC files
READ.ME	Contains on-disk instructions.
MANUAL.TXT	Contains an on-disk, printable ASCII version of this User's Guide (without graphics and without Chapter 4) as a convenience to users when this Guide is not available.

DISK NO. 1:

mssetup .su
mstest .ex
commdlg .dl_
config .fp$
ddeml .dl_
foxfont .fo$
foxprint .fo_
foxprint .tt_
foxuser .db$
foxw250a.es$
geosite .ex$
mscomstf.dl_
mscuistf .dl_
msdetstf .dl_
msinsstf .dl_
msshlstf .dl_
msuilstf .dl_
olecli .dl_
olesvr .dl_
query_a .db$
query_d .db$
query_m .db$
query_p .db$
query_r .db$
query_s .db$
query_t .db$
setup .exe
setup .in_
setup .inf
setup .lst
setup .ms_
shell .dl_
toolhelp .dl_
ver .dl_

DISK NO. 2:

geosite2 .es$
foxw2502.es$
foxw2503.es$
foxw2504.es$

In addition, both diskettes contain the following text files that can be read directly from DOS or from Windows. To view the readme file or the manual in DOS, go to the DOS prompt and type either: TYPE READ.ME /P or TYPE MANUAL.TXT /P. In Windows, use the NOTEBOOK to view.

read .me
manual .bat
manual .txt

Appendix B
GEOSITE Discussion Topics

Topics included in the GEOSITE discussion topics facility are shown in Tables B-1 through B-8.

Table B1
MAJOR TOPIC: Planning the Site Investigation Program

Discussion Topic
Geotechnical site investigation strategy for dredging projects
Scope of a complete site investigation program—sampling and testing
Scope of a limited site investigation program—field density tests only
Scope of a limited site investigation program—rock surface survey only
Factors affecting the selection of site investigation methods and equipment
Confidence and utility factors for strength testing methods
Equivalence of testing methods
Weight-volume relationships for soils

Table B2 MAJOR TOPIC: Description of Sediment Types
Discussion Topic
Overview descriptions of sediment types
Fluid mud
Highly organic soil
Cohesive (clayey) soil
Friable mixed grain soil
Cohesionless (clean granular) soil
Boulders and cobbles
Shale or cemented soils
Rock or coral

Table B3 MAJOR TOPIC: Sediment Sampling Devices
Discussion Topic
Overview of sediment sampling devices
Undisturbed, thin wall tube samplers for cohesive soils
Undisturbed, core barrel samplers for rock and hard soils
Disturbed, thick-wall split-tube drive samplers
Disturbed, gravity projectile samplers
Disturbed, vibrating tube samplers
Disturbed, bucket auger samplers
Disturbed, surface grab samplers
Disturbed, powered scoop samplers (shovel, backhoe, etc.)
Disturbed, liquid slurry samplers

Table B4 MAJOR TOPIC: Test Methods for In-Situ Strength of Sediments
Discussion Topic
Overview of test methods for in-situ strength of sediments
Field, standard penetration test (SPT)
Field, static cone penetration test (CPT)
Field, vane shear test (VST) of cohesive soil
Field, dynamic penetrometer test, thick wall tube
Field, dynamic penetrometer test, solid cone
Field, penetration rate of vibrating tube corer
Field, deceleration rate of gravity projectile
Field, hand-held sounding rod test
Field/laboratory, hand penetrometer/torvane test of cohesive sample
Laboratory, unconfined compression test of cohesive soils
Laboratory, compression test of thick wall tube cohesive sample
Laboratory, vane shear test of cohesive soils
Laboratory, direct shear test of re-densified sand sample
Rock, unconfined compression test of rock core
Rock, point load test of rock core
Rock, splitting tensile test of rock core
Rock, drilling parameter recorder (DPR) test
Rock, diver operated rebound hammer test

Table B5 MAJOR TOPIC: Material Grain Properties Tests
Discussion Topic
Overview of test methods for material grain properties
ASTM visual-manual tests of cohesive soil
ASTM visual-manual tests of granular soil
Grain size (mechanical) analysis of coarse fraction
Sedimentation (hydrometer) test for fine grain size fraction
Atterberg limits tests
Water content test methods
Organic content test methods
Specific gravity of soil grains

Table B6 MAJOR TOPIC: Methods for Accessing (Reaching) Sampling and Testing Depth
Discussion Topic
Overview of methods for accessing sampling and testing depth
Test pits and trenches
Machine operated boring methods
Hand operated boring methods
Hollow stem auger borings
Self boring sampling and testing devices

Table B7 MAJOR TOPIC: Work Platforms for Field Sampling and Testing
Discussion Topic
Overview of work platforms for field sampling and testing
Bottom supported surface platforms
Floating platforms
Bottom supported submersible platforms
Diver, operating from surface vessel

Table B8 MAJOR TOPIC: Test Methods for In-Situ Density
Discussion Topic
Overview of field test methods for in-situ density
Density test of undisturbed tube sample of soil or rock
Static nuclear gauge probe
Towed nuclear gauge
Geophysical acoustic impedance test
Resuspended density of sand sample

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13.ABSTRACT ***(Maximum 200 words)***

GEOSITE is a knowledge-based expert system that provides guidance, from geotechnical engineering experts, for the selection of equipment and methods for a subsurface investigation at an individual exploration site for a dredging project. The GEOSITE program recommends the following: (a) sediment sampling methods, (b) in situ strength testing methods, (c) methods for accessing the sampling/testing depth, (d) suitable field work platforms, and (e) material identification tests. GEOSITE is primarily intended to be used by persons familiar with basic geotechnical site investigation and testing methods, such as U.S. Army Corps of Engineers civil engineers or engineering geologists. GEOSITE may also be useful to dredging contractors, either for internal use or for use by a private geotechnical firm in their employ.

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